Search for WW/WZ Resonant Production at DØ

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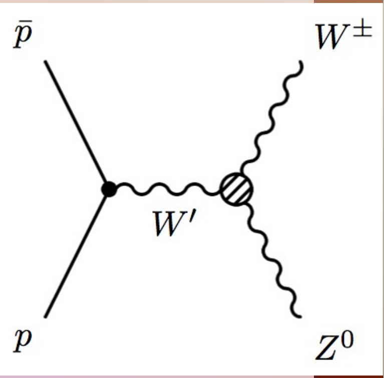
For the DØ Collaboration

Motivation

- The standard model (SM) is widely believed to be a low-energy effective theory of physics
  - New physics expected at TeV scale
- New, heavy particles may decay to WW or WZ
  - See as resonances in SM diboson spectrum
- Look combine 3 different final states
  - $WZ \rightarrow l\nu ll$ in 4.1 fb^{-1}
  - $WW/WZ \rightarrow l\nu jj$ in 5.4 fb^{-1}
  - $WZ \rightarrow lljj$ in 5.4 fb^{-1}

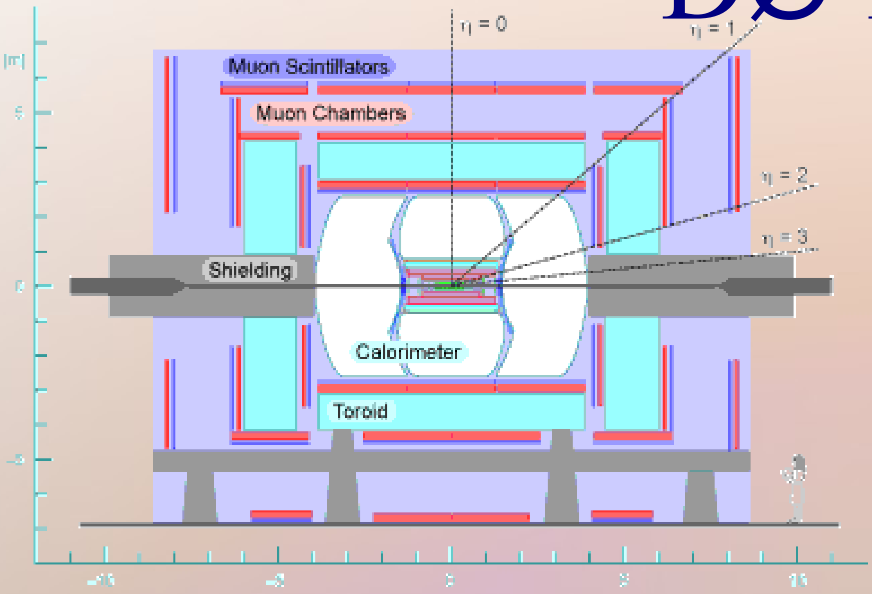
BSM Models

- We compare data to SM expectations and to Beyond the SM (BSM) theories
- The sequential SM (SSM) with a W'→WZ
  - Assumes additional SU(2) group having heavy resonances with SM-like couplings

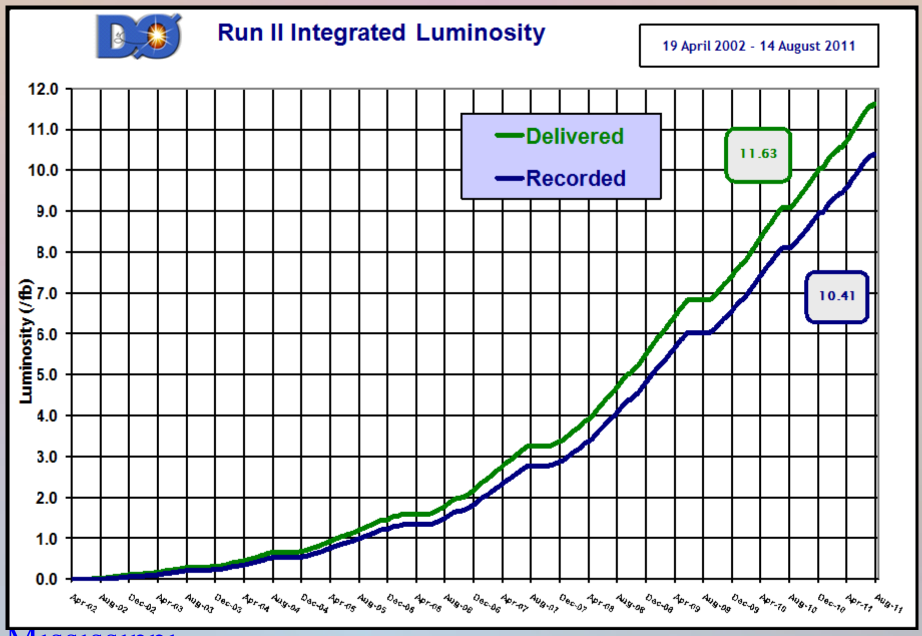


- Randall-Sundrum (RS) Models w/graviton G→WW
  - In RS Models, a warped extra-dimension exists that the graviton propagates through
  - Massive Kaluza-Klein Modes of the graviton may exist at the ~TeV scale, observable at DØ

DØ Detector



- $p\bar{p}$ collisions
  - $\sqrt{s}$ = 1.96 TeV
  - 1 bunch crossing per 396 ns

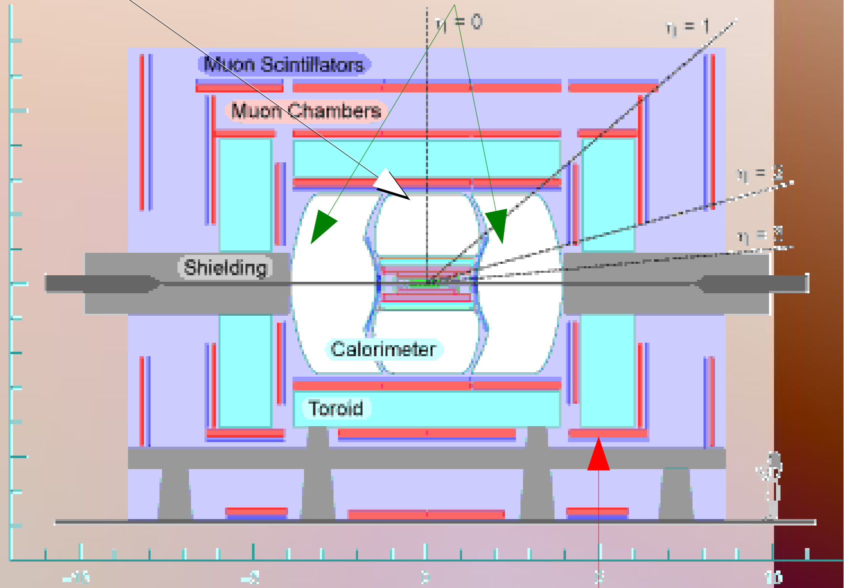


Signal and Background Modeling

- Principal backgrounds Z+jets, W+jets, $t\bar{t}$, single top, SM dibosons and multijet events
  - Z+jets, W+jets, $t\bar{t}$ modeled using ALPGEN
  - Single top modeled with COMPHEP
  - SM diboson production modeled using PYTHIA
  - Multijets estimated using data
- Both SSM W' and RS graviton modeled w/ PYTHIA
  - No interference between W and W'
  - Signal normalized to NNLO

Lepton ID

- Electrons reconstructed in Central and Endcap Calorimeters (CC and EC)
  - > 95% in EM calorimeter
  - Calorimeter and Track Isolation
  - Multivariate discriminant to reject jets
  - Consistent with track from Primary Vertex



- Muons reconstructed by matching track in muon chambers to track in inner tracker
  - Calorimeter and Track Isolation

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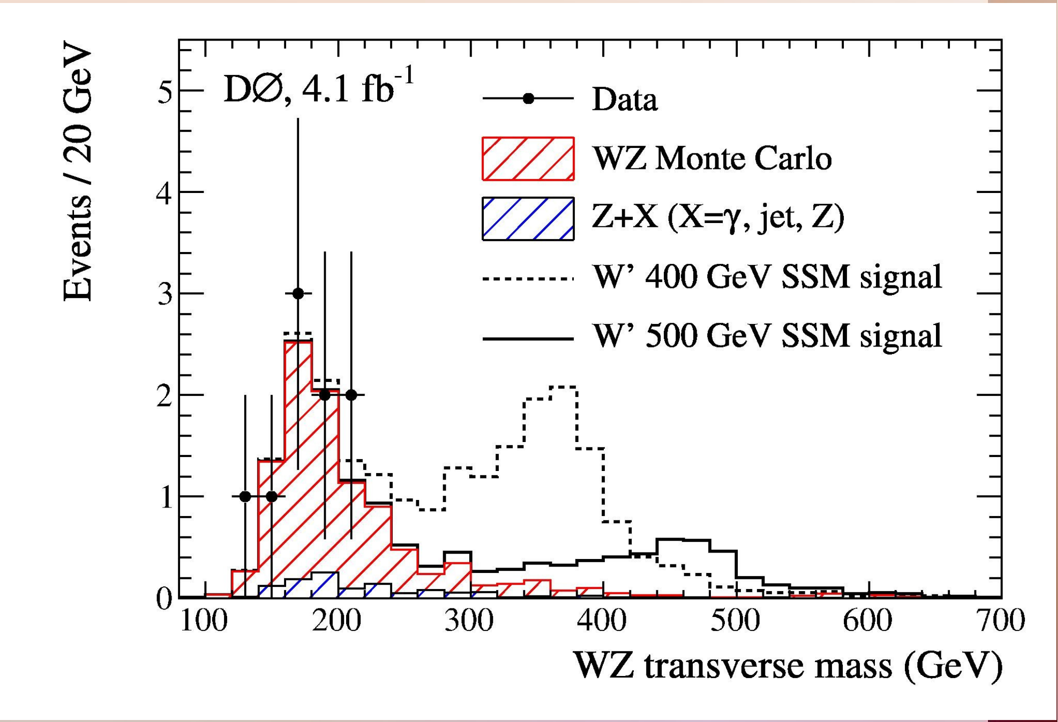
Jet ID and MET

- Jets reconstructed in CC and EC using iterative midpoint cone algorithm
  - Reject jets matched to electrons
  - Cone width $\Delta R = \sqrt{(\Delta\eta^2 + \Delta\phi^2)} = 0.5$
- Missing Transverse Energy (MET) found by taking vector sum of all calorimeter cell energies
  - Corrections for muon momentum, Jet and electron energy scales

WZ → lνll Selection Criteria



- The leptons must have $p_T > 20$ GeV
- MET > 30 GeV
- Dilepton mass consistent with Z
  - 80 (70) GeV $< M_{ee(\mu\mu)} <$ 102 (110) GeV
- Expect W, Z boosted, so require
  - $\Delta R > 1.2$ between W lepton and Z daughters

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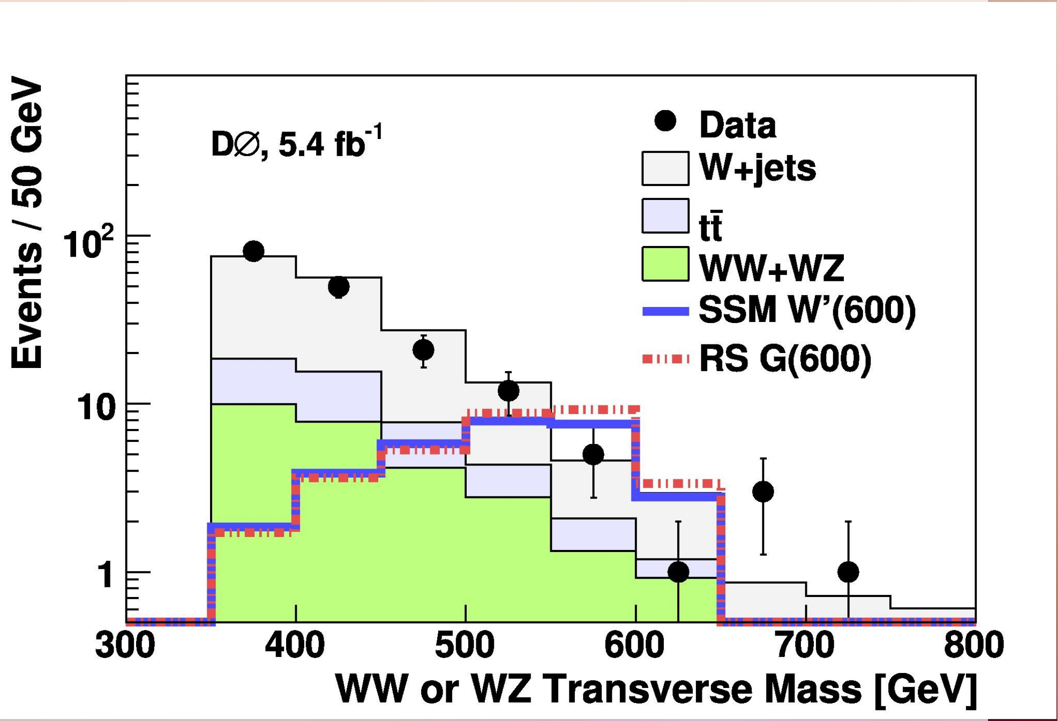
WW/WZ → lνjj Selection Criteria

- Exactly one e or μ
- The lepton must have p_T > 20 GeV
- MET > 20 GeV
- Δϕ(l,MET) < 1.5 and p_T of l+MET system > 100 GeV
- Either
  - Dijets with 70 GeV <M_{jj}<115 GeV and ΔR<1.5
  - Single jet with jet mass = $\sqrt{(E_j^2 - p_j^2)}$> 70 GeV



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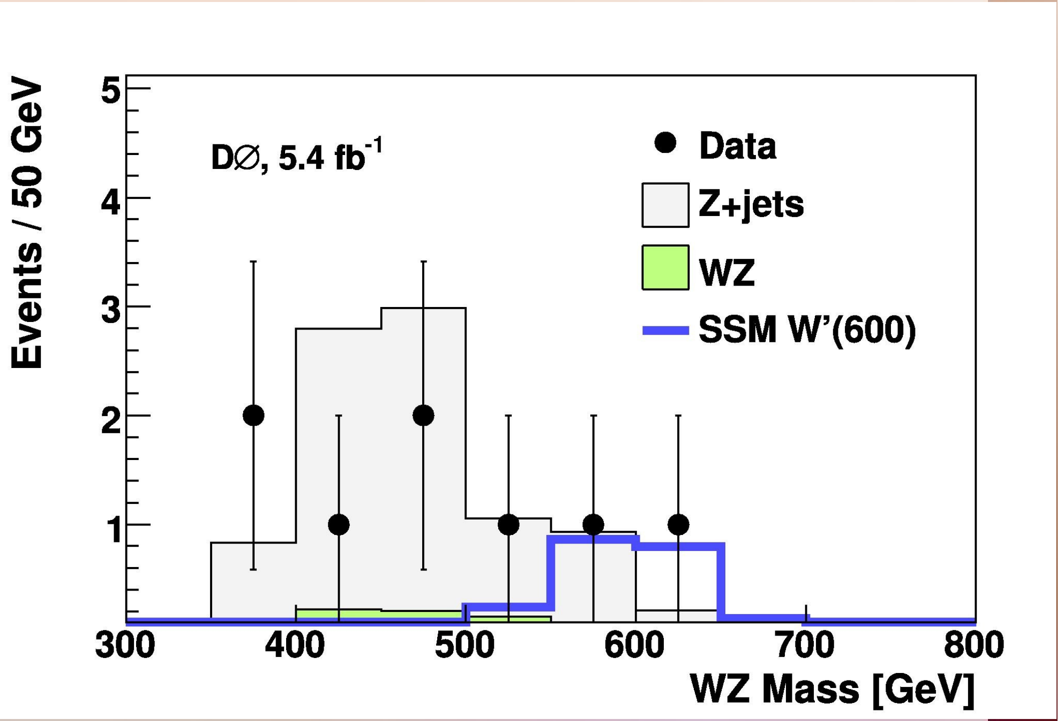
WZ → lljj Selection Criteria

- Either ee or μμ pair
- The leptons must have $p_T > 20$ GeV
- MET < 50 GeV
- 70 GeV $< M_{ll} <$ 110 GeV
- $\Delta R(l,l) < 1.5$ and dilepton $p_T > 100$ GeV
- Either
  - Dijets with 60 GeV $< M_{jj} <$ 105 GeV and $\Delta R < 1.5$
  - Single jet with jet mass $= \sqrt{(E_j^2 - p_j^2)} > 60$ GeV



High/Low Mass Regions

- Divide W'/G samples for limit setting into low mass (≤ 450 GeV) and high mass (>450 GeV) regions
  - Low mass limits include all events passing cuts
  - High mass limit requires, for lνjj and lljj
    - $\Delta\phi(l,MET) < 1.0$ and p_T of l+MET system > 150 GeV
    - $\Delta R(l,l) < 1.0$ and dilepton p_T > 150 GeV

High Mass Event Sample Composition

Process	Single lepton sample	Dilepton sample
Z+jets	3.6 ± 0.2	7.9 ± 0.8
W+jets	124.5 ± 20.3	< 0.01
Top	22.9 ± 2.5	< 0.01
Multijet	4.6 ± 0.3	< 0.01
Diboson	27.6 ± 1.4	0.8 ± 0.1
Background sum	183.2 ± 24.5	8.7 ± 0.8
Data	174	8

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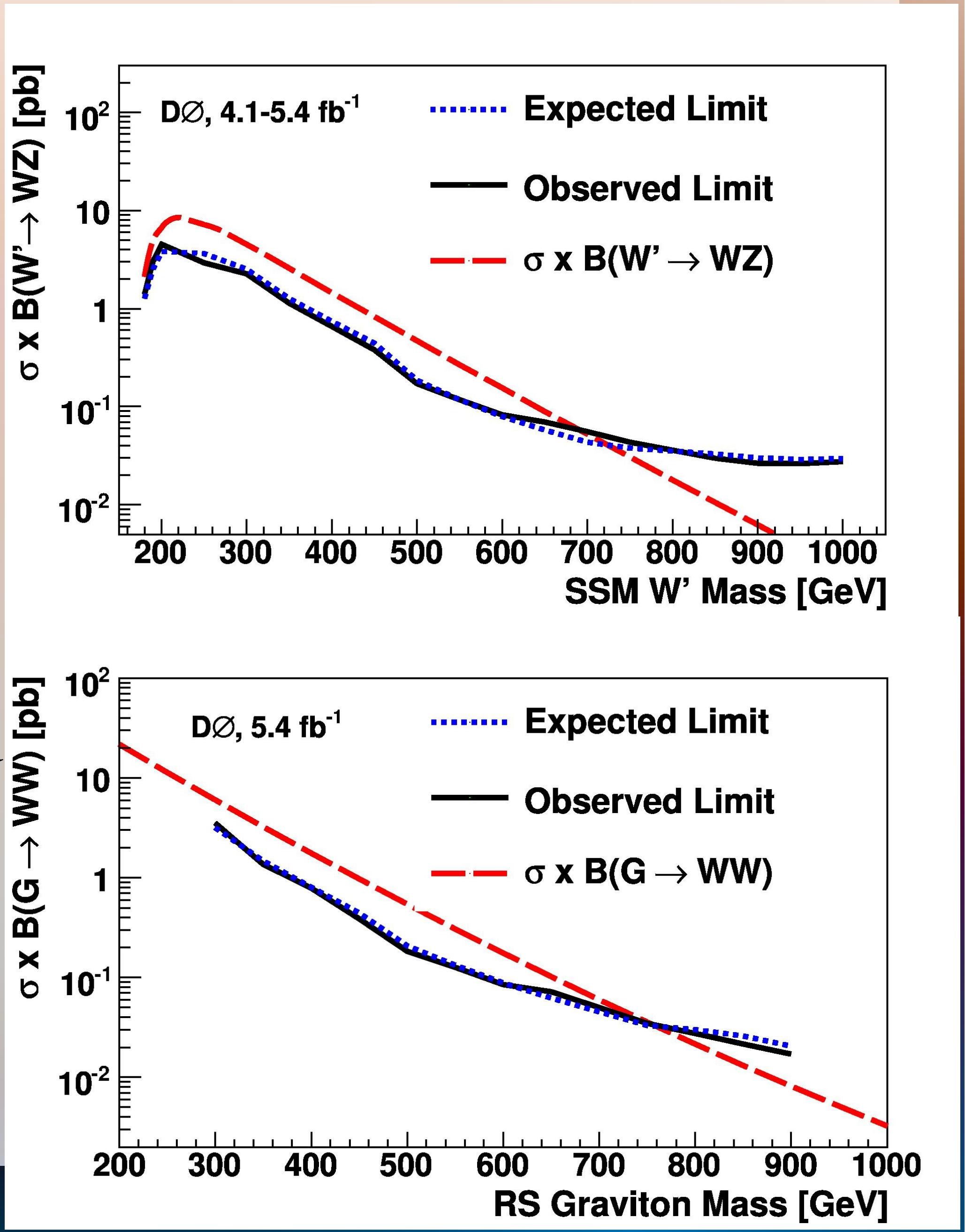
Limits Setting

- Limits set using semi-frequentist method
- Log-Likelihood Ratio (LLR) based on Poisson statistics
  - Diboson mass distribution
  - Integrate over LLR in pseudo-experiments to set confidence limits for background (CL_b) and signal+background (CL_{s+b})
- 95% C.L. exclusion limit set where $CL_{s+b}/CL_b = 0.05$



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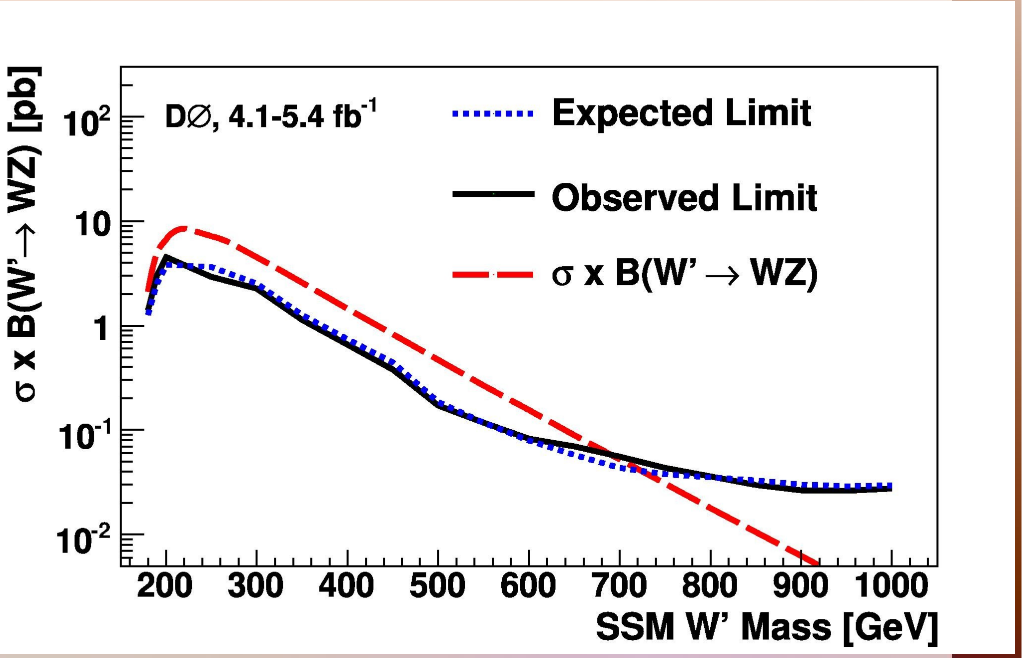
W' Limit Setting

- Limits on WZ resonance use 50 GeV bin width
- In SSM, exclude 95% CL

180 GeV<M(W')<690 GeV

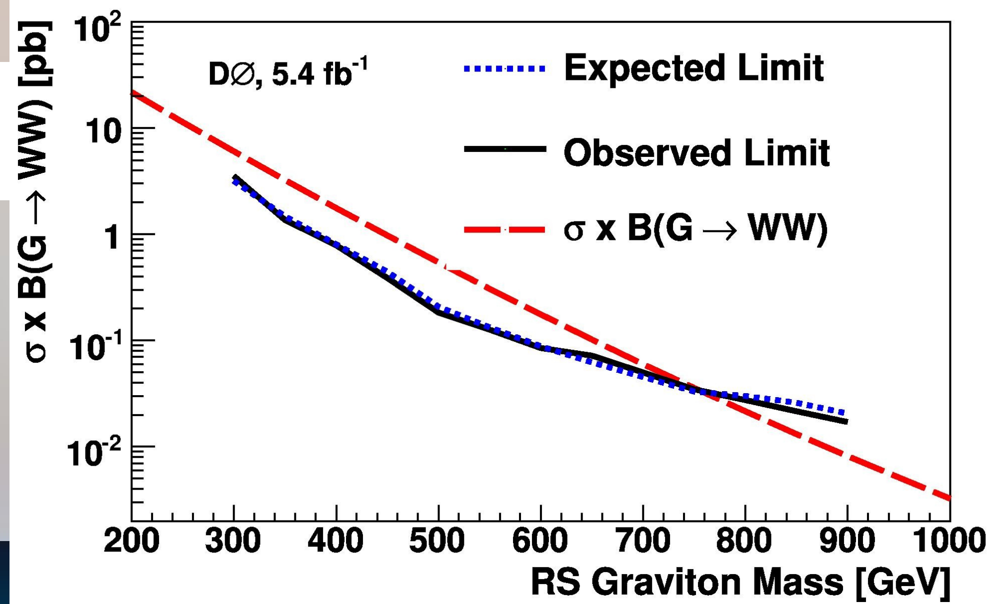


- Assume linear relation between resonance mass and total W' width and that the intrinsic width is less than experimental resolution
  - Valid for W'WZ coupling strengths up to 10 times the SSM value

Graviton Limit Setting

- Limits on WW resonance also use 50 GeV binning
- For RS graviton, assume $k/M_{Pl} = 0.1/\sqrt{(8\pi)}$, where k is the curvature scale of the warped extra dimension and M_{Pl} is the Planck mass.
- At 95% C.L, we exclude

300 GeV<M(G)<754 GeV



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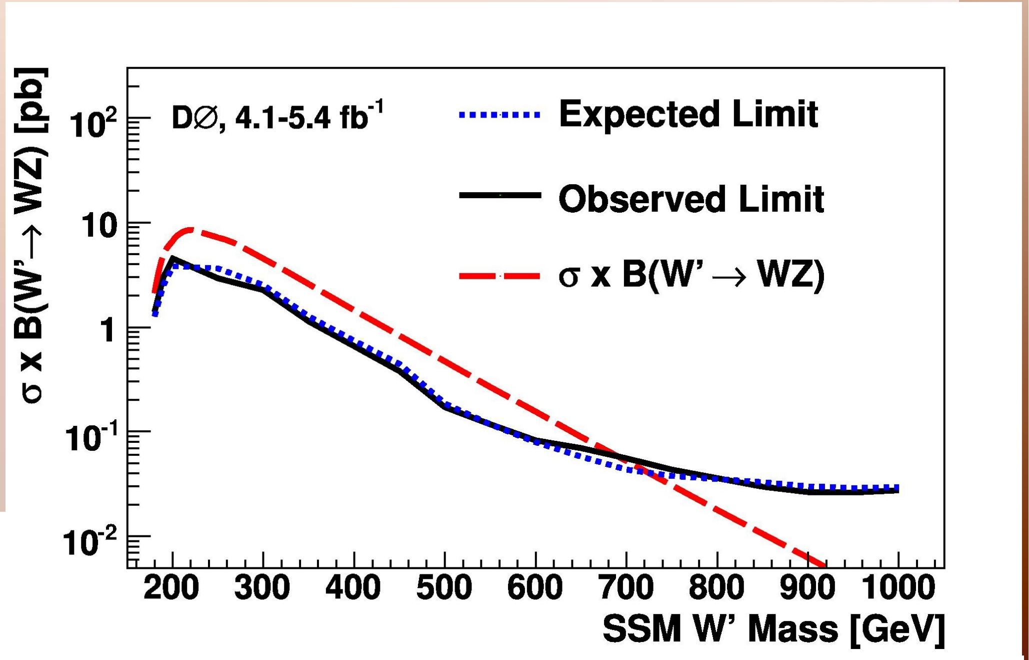
Summary

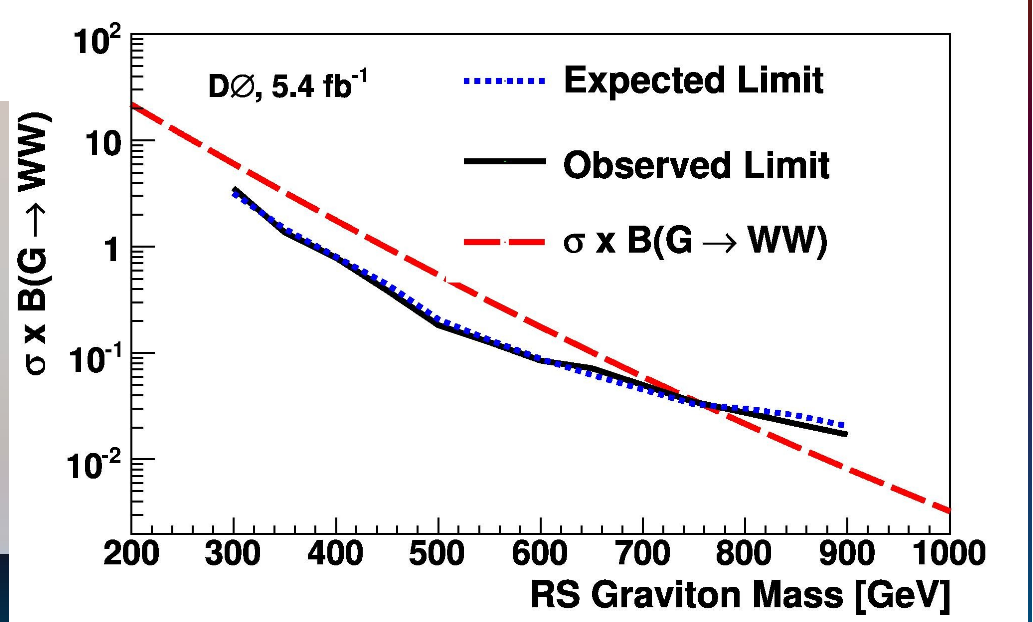
- Have set limits on WW and WZ resonances with 4.1-5.4 fb^{-1} of integrated luminosity at DØ

180 GeV<M(W')<690 GeV

300 GeV<M(G)<754 GeV

- More detail found at
  Phys. Rev. Lett. **107**, 011801 (2011)
  arXiv:1011.6278





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